Because ice seems to be the greatest hazard to aviation, the Daniel Guggenheim Foundation for the Promotion of Aviation has endowed a research laboratory in the physics department of Cornell University. A test wind tunnel in a chamber has been installed and the ice conditions have been duplicated in the laboratory. Close cooperation and exchange of information between the Airways Weather Bureau stations of the New York-Chicago Airway, the experimental laboratory and the National Air Transport (Inc.) have made this possible. Attempts of various kinds to solve the ice problem and remove the hazard are being made in the laboratory, and those that appear to have possibilities will be given further tests upon our planes this winter. All of us who are cooperating in the effort believe that the solution of the problem will be found at sometime in the near future.

EXPOSURE OF RAIN GAGES

551.508.7

By B. R. LASKOWSKI

[Read before the American Meteorological Society meeting at Des Moines, Iowa, December 27-28, 1929]

One of the main problems confronting a Weather Bureau man in establishing a new station is proper exposure for the rain gage.

It should be remembered that the standard rain gages located at the various 4,000 Weather Bureau stations in the United States furnish the only available precipitation records procurable for consultation, and for that reason they should be as nearly comparable as possible.

Prominent meteorologists, who have given this subject much thought and experiment, admit that when there is no wind large and small drops of rain, fine particles of mist, and even light snowflakes will settle down vertically to the ground, and the records of all gages within a mile or two will correspond quite closely when considered over a long period of time if there are no topographic effects to be considered. If there is a wind blowing the larger drops, falling swiftly, go into the gage without much effort, while the lighter ones are apt to be carried off to one side. Snowflakes have been known to enter a gage and then be whirled out again, making the catch decidedly deficient. This deficiency has been variously estimated from almost nothing to over 10 per cent.

Being interested in the subject and wishing to know first-hand what this difference in catch would be in Kansas, I procured a standard 8-inch gage over five years ago and set it up on a grass plot at my residence on Shawnee Avenue, Topeka, Kans., a distance of about 17 city blocks from the Weather Bureau office. The gage is well protected by trees and buildings, so that there is not apt to be any interference due to direct winds immediately at the gage. All the objects are at least as far away from the gage as their height above it. The ground between the Shawnee Avenue gage and the Weather Bureau is but slightly rolling, so there are no topographic effects worth mentioning. Whereas the Shawnee Avenue gage is located on the ground, the Weather Bureau gage is located on a flat roof of a 6-story building which is considerably higher than surrounding buildings. This roof is somewhat protected by a 5-foot parapet at the edge of the building, but the wind has a much better sweep over that gage than the one located on the ground.

Daily observations of the catch of the two gages for the 5-year period ending September 30, 1929, are offered herewith for comparison's sake. The graphs for the individual months invariably show greater catches for the ground gage. This was especially noted when the wind was gusty or squally, while at periods when the wind movement was very light or nearly calm the two gages would average about the same. In fact, the daily record shows many instances when they correspond exactly. It will be observed by the graphs that the greater differences always occurred during the summer months, when the precipitation mostly occurs during thundershowers, at which time the winds are apt to be quite high and of a shifting nature. In winter, when the precipitation is in the form of snow, as a rule, the monthly totals agree closely, and there is even then a slight advantage in favor of the ground-exposed gage. From a negligible difference in January the differences increase gradually until about the 1st of April, when the thundershower period commences, after which the increase is decided and continues so until the closing days of September, and then recedes to conditions similar to those found at the first of the year. In other words, the greatest difference in catch is during the growing season of the year. That being the case, it was decided to also compare these particular differences for the two seasons of the year, the winter and growing season.

The first charts exhibited indicate the monthly catches and we find the following:

Taking the full year's record into account and commencing with the first entry, October, 1924, the first year the catch in the ground gage was 28.47 inches and the roof gage 25.93 inches; the second year the ground gage totaled 32.47 inches and the roof gage 29.46 inches; the third year, 49.78 inches to 46.54 inches; the fourth year, 30.15 inches to 27.96 inches; and the fifth year, 38.63 inches to 34.71 inches. In other words, the annual catch in the ground-exposed gage exceeded the roof gage the first year 2.54 inches; the second year, 3.01 inches; the third year, 3.24 inches; the fourth year, 2.19 inches; and the fifth year, 3.92 inches. The average annual difference in catch for the five years was 2.98 inches. Expressed in percentages, the ground-exposed gage exceeded the roof gage the first year by 10 per cent; the second year, 10 per cent; the third year, 7 per cent; the fourth year, 8 per cent; and the fifth year, 11 per cent. The average for the 5-year period is 9 per cent.

In consulting all the charts—monthly, annual, and average—for five years for the two seasons mentioned in the fore part of this paper, the winter season, and the growing season, we have the following: During the winter season, October to March, inclusive, the ground-exposed gage collected the first season 6.04 inches, while the roof gage collected 5.68 inches; the second season the totals were 10.66 to 9.16 inches; the third season, 14.43 to 14.09 inches; the fourth season, 6.92 to 7.53 inches; and the fifth season, 15.85 to 14.48 inches. The differences this time, by seasons, amounted to 0.36 inch, 1.50 inches, 0.34 inch, −0.61 inch, and 1.37 inches. This, given in percentages, was 6, 16, 2, −8, and 9, or an average for the entire period of 6 per cent.

Taking the growing season, April to September, for study, the ground-exposed gage showed a total of 22.43 inches the first season, as compared to 20.25 inches on the roof; the second season, 21.81 to 20.30 inches; the third season, 35.35 to 32.45 inches; the fourth season, 23.23 to 20.43 inches; and the fifth season, 22.78 to 20.23 inches. The differences here are for the first season, 2.18 inches; the second, 1.51 inches; the third, 2.90 inches; the fourth, 2.80 inches; and the fifth, 2.55 inches. The average for the entire period totaled 2.39 inches. Converting these differences to percentages again, we have the following: 11, 7, 9, 14, and 12, and the average for the period 11 per cent.

A difference of 10 per cent in the actual amount of rainfall would be a very important matter in the semiarid sections of the West.

Since the following study corroborates what others have found out in the past as regards the difference in catch between ground-exposed and elevated gages, it must be admitted that the Weather Bureau is doing the proper thing by insisting that rain gages should be located on the ground whenever it is at all possible, so that uniform records may be obtained.

Monthly catch of precipitation

GROUND-EXPOSED GAGE

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1924										0.60	1.04	1.95
1925	0.44	0.62	1.39	4.67	1.87	6.86	3.45	1.08	4.50	4.20	1.19	0.28
1926	1.15	1.74	2.10	2.79	3.37	2.55	2.53	3.64	6.93	6.04	1.40	0.87
1927	0.75	0.63	4.74	6.41	2.83	8.62	7.00	7.08	3.41	2.62	0.73	0.67
1928	0.03	2.30	0.57	2.67	2.84	5.77	3.55	6.13	2.27	1.68	6.97	1.35
1929	2.51	1.32	2.02	5.24	6.49	4.34	1.91	2.69	2.11			
Means	0.98	1.32	2.16	4.36	3.48	5.63	3.69	4.12	3.84	3.03	2.27	1.02

ROOF-EXPOSED GAGE

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1924										0.66	0.88	2.16
1925	0.28	0.55	1.15	4.40	1.92	6.05	3.44	0.87	3.57	3.28	1.12	0.19
1926	1.12	1.39	2.06	2.71	3.01	2.49	2.42	3.27	6.40	4.90	1.42	0.97
1927	0.73	0.76	5.31	5.10	2.69	8.19	6.23	6.80	3.44	3.05	0.72	0.78
1928	0.02	2.43	0.53	2.69	2.46	5.11	2.75	4.91	2.51	1.47	6.08	1.24
1929	2.42	1.26	2.01	5.26	5.96	3.18	1.70	2.64	1.49			
Means	0.91	1.28	2.21	4.03	3.21	5.00	3.31	3.70	3.48	2.67	2.04	1.07

Annual catch of precipitation

[Year, October to September, inclusive]

	Ground-exposed gage	Roof-exposed gage	Difference in catch	Difference in catch
YEAR	*Inches*	*Inches*	*Inches*	*Per cent*
First	28.47	25.93	2.54	10
Second	32.47	29.46	3.01	10
Third	49.78	46.54	3.24	7
Fourth	30.15	27.96	2.19	8
Fifth	38.63	34.71	3.92	11
Means	35.90	32.92	2.98	9

CATCH DURING THE WINTER SEASON

[Season, October to March, inclusive]

SEASON				
First	6.04	5.68	0.36	6
Second	10.66	9.16	1.50	16
Third	14.43	14.09	0.34	2
Fourth	6.92	7.53	−0.61	−8
Fifth	15.85	14.48	1.37	9
Means	10.78	10.19	0.59	6

CATCH DURING GROWING SEASON

[Season, April to September, inclusive]

SEASON				
First	22.43	20.25	2.18	11
Second	21.81	20.30	1.51	7
Third	35.35	32.45	2.90	9
Fourth	23.23	20.43	2.80	14
Fifth	22.78	20.23	2.55	12
Means	25.12	22.73	2.39	11

A FACTOR IN THE TEMPERATURE OF THE STRATOSPHERE

551.524 : 551.510.5

By W. J. HUMPHREYS

When we first heard, some 30 years ago, that the temperature of the air rather rapidly decreases with increase of height up to the level of the highest currus, or wispy, clouds, and from there on as far as a balloon could carry a thermometer remains practically constant, we just didn't believe it—not all of it. We accepted, of course, the first part of the statement to the effect that the greater the height the colder the air. We had gotten used to that from mountain climbing and from the records kept by balloonists. Then, too, we had found a good physical reason why it should be so, or at any rate an essential part of that reason. It is this: Ascending air expands, because the pressure on it grows less and less by the weight of the air left below, but it expands against the weight of the air that still is above it, and therefore does work. Now, to do work it must expend energy, and its available energy for this purpose is its heat. Evidently then, ascending air, expanding as it goes, and doing work at the expense of its own heat, must get colder and colder with increase of height. All this is in perfect accord with our laboratory experiments, and so we accepted the fact of the decrease of temperature with increase of height as a phenomenon which, if not entirely selfevident, at least is so easy to explain as scarcely to merit a passing thought.

That is where we made at least two mistakes. In the first place, even when it does occur it isn't half so easy to explain as we thought it was, and, in the second place, it doesn't occur at all in the high atmosphere. Of course the pressure continuously decreases with gain of level beyond the highest clouds, just as it does below them, and so asking us to believe that the temperature does not also decrease up there with increase of level just as it does in the cloud region was asking too much; it was contrary to our laboratory experience. However, after hundreds of records obtained by sounding balloons (small balloons carrying only registering instruments) had shown that immediately the uppermost cloud level is passed the temperature really is practically constant, why of course we had to accept it as a fact, and revise our explanations accordingly.

In the end it all came out simply enough. Our previous reasoning had been perfectly correct, but the premises were sadly deficient. We had left out of account the effects of radiation, and had set no limit to convection. Throughout all that portion of the atmosphere in which clouds of any kind occur, that is, from the surface up to the height of 6 to 7 miles, in middle latitutes, and 8 to 10 miles in tropical regions, there is decided convection—change in level of individual masses of air. The temperature, therefore, of each such mass does vary with height, and as the whole of this portion of the atmosphere is involved in this continuous vertical turnover so also does this temperature relation extend to its every portion. But beyond the clouds vertical convection, if it exists at all, is so slow as to be practically absent so far as temperature effects are concerned. Here no one portion of the air changes temperature with altitude for the good and sufficient reason that it neither rises nor falls. Heat is not added to it by compression, nor taken from it by